On page 14, line 11, after the word "level", please delete "1".

On page 18, line 22, please delete "less than" and substitute in place thereof --at least--.

On page 20, line 27, after the word "comprising", please delete "a first end 82 having".

On page 22, line 5, please delete "96".

REMARKS

Applicants gratefully acknowledge the interview granted to Applicants' Attorney by Examiners Nguyen and Rose on January 16. In the discussion of chemically bonded, metal bonded single layer superabrasive tools, the existence of prior art showing chemical bonding of the superabrasive grain to the braze was discussed. Applicants have reviewed the technology and submit herewith as Appendix A patents relevant to the discussion. These patents describe chemically bonded superabrasive grain in particular types of brazes.

Applicants have corrected certain typographical errors in the specification by amendment herein. Several corrections relate to inconsistencies between the Figures and the text describing the Figures. In each instance, support for the amendment may be found in the text or Figures as originally filed.

Applicants have added two additional dependent claims reciting the particular classes of construction and industrial tools for cutting very hard materials wherein the invention is particularly useful. Support for the new claims may be found in the Figures and in the specification, page 20, lines 5-6. Applicants have substituted the term "superabrasive" for the testing parameters originally recited in claim 1. The recited parameters, by definition, include only superabrasive grains and the amendment is not intended to change the scope of the claim, but merely to simplify the language.

Applicants have amended claims 1 and 28 directed to the tools of the invention to further describe the three-dimensional structure of the tools responsible for the improved performance in

cutting rate, penetration rate and tool life. Support for the amendments may be found in the text on pages 6, lines 27-28, page 7, lines 1-28, page 8, lines 1-18, and page 9, lines 1-19, and in the Figures.

Restriction Requirement:

Applicants hereby confirm the election, with traverse, of the species shown in Figure 3 and claimed in claims 1, 3-26, 28-32, and 33-34, for examination.

Objection to the specification:

On page 7, lines 10-15, the phrase "the theoretical hexagonal close packing of spheres" refers to a packed lattice crystal structure of the type described in the attached excerpt from Electronic Processes in Materials, L. V. Azaroff and James J. Brophy, McGraw-Hill Company, N.Y., 1962, p.17, contained in Appendix B. As applied to the invention, this phrase refers to the placement of the abrasive grain on the surface of the tooth, and is used to define the percent concentration of the grain on the surface relative to a theoretical closest packed layer of grain on the surface (i.e., 100% packed grain distribution on the surface of the tooth).

Rejection Under Section 102:

Applicants' invention relates to cutting tools comprising a single layer of abrasive grains **chemically bonded** onto a monolithic substrate having a plurality of contoured teeth extending from a substrate surface. Claims 1 and 28, independent claims directed to the tools of the invention, have been amended to more precisely describe the tooth structure and the function achieved by the structure.

The teeth on the tools of the invention preferably have a negative rake angle in the direction of motion (claim 28). In certain embodiments, the teeth of the tools will have a negative rake angle in either a clockwise or a counterclockwise direction of motion (e.g., Fig. 2). The tools of the invention

preferably comprise superabrasives, such as diamond and CBN, which are materials characterized by a relative strength index under the FEPA standard of at least one minute (claim 1).

The tools of the invention comprise a plurality of cutting levels of abrasive grains parallel to the substrate surface *and oriented such that at least a portion of each cutting level of each tooth overlaps each of the other parallel cutting levels of the tooth.* As a result of this structure, the bonded grains on the lower parallel cutting levels support the grains in the uppermost cutting level which are in contact with the workpiece during cutting. In addition, each tooth is contoured such that *in the uppermost cutting level a ring of the abrasive grain around the contoured surface of each tooth is in contact with the workpiece during cutting.* See page 8, lines 17-24, and the Figures. As a result of this structure, the grains bear the majority of the load or cutting forces, the penetration rate of the tool is improved, a freer cut is achieved and the steady state cutting rate equilibrium is extended, with maximum utilization of grain and tool life.

Prior art tools may be distinguished from the tools of the invention in several ways. In most prior art tools comprising a single layer of abrasive grain, the grain has been adhered to a substrate by electroplating or by an adhesive or by some other physical bonding mechanism. The strength of a physical bond is significantly less than the strength of a chemical bond-such as the braze used to bond the abrasive grain to the tools of the invention.

To chemically bond diamond or CBN abrasive grain to a metallic substrate surface, the bonding agent is preferably an active braze or other composition comprising an element reactive with the carbon or the nitride on the surface of the grain. For example, the preferred braze used in the invention may contain a nickel-chromium material, or a bronze-titanium material. (See page 19, lines 9-17.) In addition, the grain must be bonded to the substrate at a temperature of about 1000-1100 °C for chromium or about 850-950 °C for titanium under an inert atmosphere to form a chemical bond between the abrasive grain and the metal substrate.

The Scott patent discloses a chain-saw comprising cutting inserts made of abrasive grain bonded in the openings of a wire mesh carrier mounted on rubber pads and glued to links of the chain. As may be determined by reviewing the 4,925,457 and 5,049,165 patents (attached hereto in Appendix C) which are cited in column 4, lines 50-68, together with the text in column 5, lines 15-17, the abrasive grain used in the cutting elements of the Scott chain saw **is not chemically bonded to the mesh substrate**.

The Scott tool does not comprise a monolithic substrate, nor a substrate surface, nor a plurality of teeth extending therefrom. Furthermore, although the mesh cutting element is inclined in a negative rake angle relative to the path of travel of the chain, it can be seen from Figures 4, 5, 6, and 7 that the tool does not comprise a plurality of cutting levels parallel to the substrate surface *and oriented such that at least a portion of each cutting level of each tooth overlaps each of the other parallel cutting levels of the tooth*. A row of physically bonded grain oriented perpendicular to the direction of motion and across the width of the top surface and an upper part of the side surfaces of the cutting link contacts the workpiece during cutting. The tool does not provide cutting levels having *a ring of grain around the contoured surface of each tooth* and in contact with the workpiece so that *substantially all superabrasive grain within the ring simultaneously engages in cutting.*

For these reasons, the Scott patent does not anticipate the invention.

Rejection under section 103:

Viewing the invention as a whole, a technology taught to be useful for constructing cutting elements on discrete moving parts, such as the Scott chain links, cannot be transferred directly to cutting tools having rigid, monolithic cutting elements such as core drill bits, saw blades or cutting wheels. A significant amount of experimentation would be necessary to transfer the cutting element technology. The engineering problems and associated cost factors are entirely different for each of these tools.

The structure of the chain saw links and the geometry created by the structure cannot yield the benefits in grain and tool life, penetration rate and steady state cutting equilibrium realized by the structures of Applicants' invention. These benefits are due to the contoured surface designs of the teeth. The teeth are mounted on a monolithic substrate in which the uppermost cutting level presents a ring of the abrasive grain around the contoured surface of each tooth to the workpiece during cutting, and each tooth provides overlapping cutting levels comprising chemically bonded grain. The overlapping levels support the uppermost, active cutting level and protect the tool substrate. See page 8, lines 25-27 and page 9 and Figure 2.

The Scott patent fails to suggest the benefits of chemically bonded abrasive tools. The mesh cutting element assembly suggested by Scott at column 8, lines 16-18, would have significantly inferior tool life compared to tools of the invention. In this respect the mesh cutting elements of the chain saw links resemble the electroplated single layer abrasive tools of the prior art. Furthermore, the mesh cutting elements are expected to be inferior to the electroplated tools because the mesh cutting elements do not protect the entire surface of the chain links nor the connecting mechanisms on which the links rotate. Thus, while the mesh cutting elements may be an improvement over the chain links known in the art, irrespective of whether a chemically bonded grain is used, they are not an improvement over the cutting structures used in Applicants' tool designs.

The Scott patent fails to suggest the benefit of a cutting tooth geometry presenting a ring of abrasive grain around the tooth in each cutting level during cutting. Scott teaches the presentation of a single row of abrasive grain at a given height (i.e., a "cutting level") as the cutting element. Thus, other, non-abrasive, parts of the chain link at the same height as the "cutting level" are presented to the workpiece. This increases the area of contact of tool components other than the abrasive grain with the workpiece, thereby decreasing cutting efficiency. Without the benefit of a ring of chemically bonded grain around the link to protect the moving parts of the links and the mesh substrate that

supports the grain from contact with the workpiece and debris, the support means are likely to wear before the abrasive grain life is exhausted.

The negative rake angle design of Scott does not suggest the benefits in mechanical strength achieved by overlapping the parallel cutting levels within a tooth. This distinctive vertical stacking of cutting levels within the teeth of the invention may be readily observed by viewing the Figures in the specification and comparing them to Figure 4 of Scott.

The mechanical strength achieved with the contoured teeth of the invention is much more critical to the working stresses applied to the rigid cutting tools of the invention than it is to those applied to the flexible chain linked cutting elements of the Scott saw. This is an example of the inability to directly transfer the Scott technology to the tools of the invention.

The negative rake angle is a preferred way to achieve the structural and functional objectives of the invention. However, absent the combination of structural elements set forth in the claims, a negative rake angle design presenting a row of physically bonded grains supported on a mobile chain link (i.e., the Scott design) would display cutting performance far inferior to that of the invention.

In addition, the structure of the tools disclosed by Scott lack the benefit of reduced undercutting. Undercutting is the premature wear of the steel or other substrate surface caused by contact with hard debris generated during cutting concrete, and the like, while the grain retains useful life. Although the sides and top of the cutting elements shown in Figure 3 of Scott will protect a portion of the link bearing that cutting element from erosion, much of the remaining surface of the cutting link and the exposed metal parts in the link trailing the protected link have no protection from concrete particles and other abrasive debris generated by the cutting link. As each row of grain wears down within each cutting element, the exposure of the trailing and cutting links increases and the risk of premature tool failure increases.

In contrast, the tools of the invention are designed so that the ring of chemically bonded abrasive grain around each tooth on the lower levels of the plurality of overlapping cutting levels of abrasive grain functions as a surface guard against the undercutting of the metal support structure of the teeth. The only supporting structure exposed to the workpiece or its debris is the cross-sectional area of the tooth within the operative cutting level. This supporting structure is designed to wear as the grain wears to expose the next cutting level. Thus, grain and support wear are synchronized. As the cutting levels wear, the amount of protection remains constant until the lowermost cutting level is in use. See page 14. The design ensures full grain life, improved tool life and protection from loss of teeth due to undercutting during tool usage.

None of the prior art directed to rigid cutting tools such as blades and core drills suggests the benefits of the tooth structure and geometry utilized by Applicants. Nor do these references suggest the improvements achieved by the combination of the tooth structure and geometry with chemically bonded grain in a metal single layer tool.

CONCLUSION

In view of the amendments submitted herein, Applicants respectfully request an allowance of the claims.

Respectfully submitted,

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